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Ethanol Production, Corn Gluten Feed, and EC Trade

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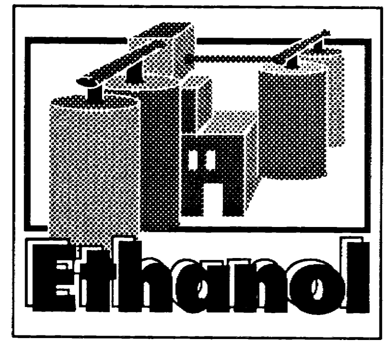


The profitability of ethanol depends not only on sales of ethanol but on sales of several coproducts of corn wet-milling such as corn gluten feed (CGF). CGF demand and supply are affected by several European Community (EC) and U.S. policies, such as EC grain price supports and U.S. energy policies. Changes in existing policies and programs could have a significant effect on the CGF market and, consequently, on the profitability of ethanol production. This report examines the implications of several policy options on demand, supply, and price of CGF and on the profitability of ethanol production. The policy changes examined include: (1) the effect of proposed changes in EC farm and trade policies, and (2) the effect of increased ethanol production due to proposed U.S. environmental policies, such as the reauthorization of the Clean Air Act.

The United States is the world's leading supplier of CGF, a byproduct of ethanol and high-fructose corn syrup (HFCS) production. Total CGF production in the United States increased from about 2 million tons in 1975 to 6.8 million tons in 1990. Ethanol production accounted for about 2 percent of total CGF production in 1980, and about 25 percent in 1990. Most of the remainder of CGF is supplied through HFCS production.

Production of CGF is affected as much by EC demand as by U.S. supply. If EC agricultural policy reform reduces EC grain prices, the price gap between EC grains and world grains will decline. As EC grains become more attractive to EC feed compounders, the EC demand for U.S. CGF will fall, putting downward pressure on CGF price. However, any expansion in ethanol production would also increase the U.S. corn price, which implicitly raises the CGF price floor. The net effect is a CGF price close to the corn price, with CGF supplies going to both the EC and U.S. markets.

CGF would continue to be priced competitively in the EC, relative to EC grains and imported oilseeds, so the EC would continue to import a portion of total U.S. supply. However, as CGF prices fall, U.S. feed manufacturers will bid CGF away from the export market. Wet-millers will be able to dispose of the increased supply of CGF, but at lower prices. As prices for CGF fall, due to increased CGF supply and EC grain prices, the CGF coproduct credit will also decline, affecting the cost of wet-milling.

What Is CGF?

CGF is a coproduct of the corn wet-milling process. This process separates the corn kernel into four products: germ, hull, gluten, and starch (Hohmann and Rendleman, 1993). The primary value of the corn kernel is in the starch, which can be further processed into ethanol, HFCS, and other industrial and food products (Schmidt and Gardiner, 1988). Along with CGF, other coproducts of wet-milling include corn gluten meal and corn oil (table 1). CGF contains 22 percent protein, one-half the protein content of soybean meal but twice the protein content of most feed grains.

CGF is one of several ingredients used in manufactured livestock feeds. Feed compounders use feed grains (corn, wheat, barley), oilseed meals (soybeans, cottonseeds), grain proteins (wheat feeds), animal proteins (meat and bone meal), and minerals (vitamins, drugs, premixes) to manufacture feeds. In Europe, nongrain feeds are used extensively in manufacturing commercial livestock feeds. Nongrain feeds, which the EC classifies as any of several cereal substitutes that are imported into the EC with either no or very low import levies, include CGF, manioc, sweet potatoes, and citrus pulp (Agra Europe, 1986). The term "cereal substitute" can be misleading because few of these ingredients are perfect substitutes for grains and most must be combined with other ingredients to meet nutritional requirements (Hillberg, 1986). Indeed, there is considerable controversy over labeling CGF as a cereal substitute due to its high protein content.

Feed compounders select combinations of ingredients based on ration type (swine, cattle, poultry), nutritional requirements, nutritional value of each ingredient, availability, and price. Although compounders may be restricted by nutritional and technical constraints, they can choose from multiple feed ingredients (De Veer, 1984).

A typical ration minimizes total feed cost subject to nutritional constraints on energy, protein, and mineral ingredients. Constraints could also include minimum and maximum levels of specific ingredients, depending on the type of ration. For example, although corn gluten feed can be used in higher proportions in cattle rations than in swine or poultry rations, it is limited for nutritional reasons to about 30 percent of a total cattle ration (McKinzie, Paarlberg, and Huerta, 1986).

Table 1--Products and yields of corn wet-milling

Product	Before 1990	After 1990
1 bushel of corn produced(s):		
Ethanol	2.5 gallons	2.5 gallons
Corn gluten feed	12.5 pounds	13.5 pounds
Corn gluten meal	2.6 pounds	2.65 pounds
Corn oil	1.6 pounds	1.55 pounds

Source: U.S. Department of Agriculture, *Sugar and Sweeteners, Situation and Outlook Report*, various issues.

While the use of commercial feed has been growing in recent years, many countries also rely on grazing and onfarm feeding for livestock nutrition. For example, U.S. compound feed production increased from about 30 million tons in 1973 to 40 million tons in 1989, while EC compound feed production increased from about 60 million tons in 1973 to 100 million tons in 1989. The growth in production of commercial feed reflects not only increases in animal herds as population and meat demand increase but also structural change in the livestock sector. Over time, many traditional livestock operations have become increasingly specialized, relying more on grains and purchased feeds and less on grazing. This trend is likely to continue in both the developed and developing world (Mergos, 1989).

CGF Production, Trade, and Price

The United States is the world's major supplier of CGF. Production of CGF is determined by the demand for the products of primary value: ethanol and HFCS. Total CGF production in the United States increased from about 2 million tons in 1975 to 6.8 million tons in 1990 (table 2, fig. 1). Ethanol production accounted for about 2 percent of total CGF production in 1980, but 25 percent by 1990. Most of the remainder of CGF is supplied through HFCS production.

In 1975, about half of U.S. CGF production was exported to the EC; today, close to 90 percent goes to the EC. CGF exports increased from about 1 million tons in 1975 to 5.9 million tons in 1990. Exports have steadily increased since the mid-1970's, except in 1985, when the EC dairy quota, a large EC grain harvest that encouraged onfarm feeding, and the effects of a strong dollar reduced EC demand for U.S. CGF (Schmidt and Gardiner, 1988). The value of CGF exports increased from \$98 million in 1975 to \$687 million in 1990, but CGF exports still represent a small portion of the total value of U.S. agricultural exports (0.45 percent in 1975 and 1.7 percent in 1990).

The profitability of wet-milling depends on sales of CGF, as demonstrated by the change in wet-milling coproduct credits since 1981. (Coproduct credits are computed by multiplying the price of the coproduct

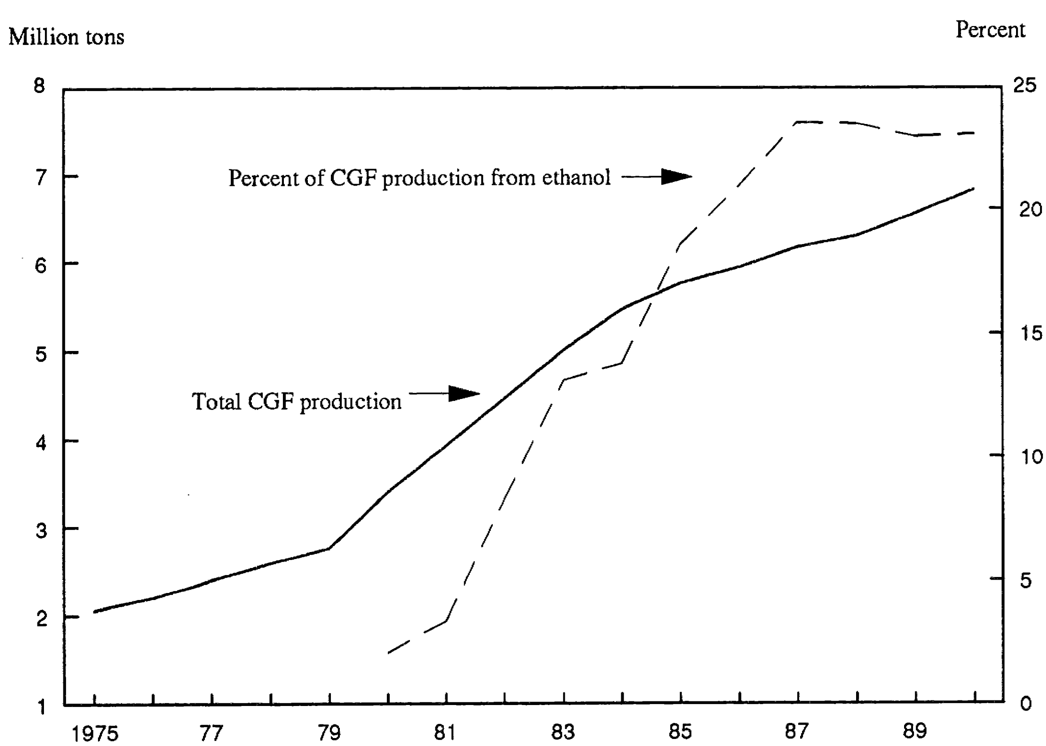
Table 2--U.S. production, exports, and value of CGF, selected years

Year	CGF production	CGF exports	Share exported	Value of CGF exports	Value of agricultural exports	CGF share of total agricultural exports
	---1,000 tons---		*Percent*	*---Million dollars---*		*Percent*
1975	2,050	969	47	98	21,578	0.45
1980	3,395	2,794	82	429	40,481	1.06
1985	5,758	3,676	64	451	31,201	1.45
1990	6,818	5,927	87	687	40,203	1.71

Figure 1

U.S. corn gluten feed production

Ethanol production accounts for an increasing share of CGF production.



by the amount of the coproduct produced per gallon of ethanol or primary product). These credits are used by wet-millers to measure the contribution of coproduct sales toward offsetting the cost of corn, the primary wet-milling input. Since 1981, the coproduct credit for CGF has ranged from \$0.20 to \$0.32 per gallon of ethanol (fig. 2). CGF had the highest coproduct credit in 1983 and 1988.

In the United States, CGF is generally priced at a discount to soybean meal due to its lower protein content, but priced at a premium to corn and other coarse grains. Yet, U.S. CGF price fell below U.S. corn price in several years (fig. 3). This price anomaly occurred during periods of low export demand and low soybean meal prices. In the EC, where grain prices have been supported, CGF sells at a discount to most grains. For example, the Rotterdam price of CGF has generally been at least 25 percent lower than the EC threshold price (the price at or above which imported grain enters the EC) for corn and wheat. The EC threshold prices for wheat and corn are significantly higher than U.S. prices. U.S. wet-millers are able to market CGF in the EC precisely because of these pricing relationships. High EC price supports allow CGF to be priced at a discount to EC feed ingredients. But at the world CGF price, CGF is too expensive, relative to other feed ingredients, to be used extensively in the United States.

The United States does not directly subsidize CGF production, but the U.S. wet-milling industry is influenced by government programs and subsidies that affect the demand for and supply of ethanol. CGF supply also responds to subsidies to ethanol blending. Ethanol-blended fuels are exempt from 5.4 cents of the Federal excise tax on gasoline. At the 10-percent blending rate allowed under fuel standards, the tax exemption is effectively a subsidy of 54 cents per gallon of ethanol. The Federal Government has also provided loan guarantees to encourage ethanol plant construction and many States provide financial incentives.

In addition, the sugar program, which includes price supports for sugarcane and beet sugar and import quotas for raw and refined sugar, raises the U.S. domestic price of sugar. Higher sugar prices encourage production of HFCS, an alternative sweetener, which increases production of CGF and other wet-milling coproducts. Other programs that affect CGF include the Conservation Reserve Program (CRP) and commodity programs that support the price of corn and reduce ethanol and HFCS production.

CGF Use in the EC

As a component in EC feeds, CGF comprises a relatively small share of total feed ingredients. As of 1984 (most recent data available), CGF provided less than 6.3 percent of total energy needs and less than 7.2 percent of total protein needs, with the bulk of energy and protein supplied by forage crops (Koester, 1988). For example, in the mid-1980's, forage accounted for roughly 57 percent of EC animal nutrition, with the remainder supplied through commercial feeds. Compound feeds contain approximately 59 percent grains, 21 percent oilseed meals, and 20 percent nongrain feeds (Koester, 1988). Because corn gluten feed is approximately 20 percent of total nongrain feed, corn gluten feed accounts for about 4 percent of EC feed compounds and about 2 percent of total feed ingredients (Koester, 1988).

Although CGF's contribution to total animal nutrition is small because of the reliance on forage, CGF has shown tremendous growth as an ingredient in EC compound feeds. In the EC, cereal substitutes are heavily used in regions close to ports, such as the Netherlands. Inland use is less intensive and depends on transportation costs and price differentials between locally produced cereals and the availability of other nongrain feeds (De Veer, 1984). Between 1973 and 1987, total nongrain feed use in the EC remained relatively stable at 18-23 million tons per year, but CGF use increased from less than 1 million tons (4 percent of total nongrain feeds) to nearly 5 million tons (20 percent) during the same period (fig. 4). The increase in CGF imports is attributed to several causes: (1) high EC support prices for EC grains, which cause EC grains to be relatively expensive feed ingredients, (2) variable levies on imports of corn and other feeds, which restrict entry of cheap feed ingredients, (3) duty-free or low-duty nongrain feed imports, which encourage imports of feed ingredients, (4) increased

Figure 2

Wet-milling byproduct credits

Byproduct credits vary with byproduct prices.

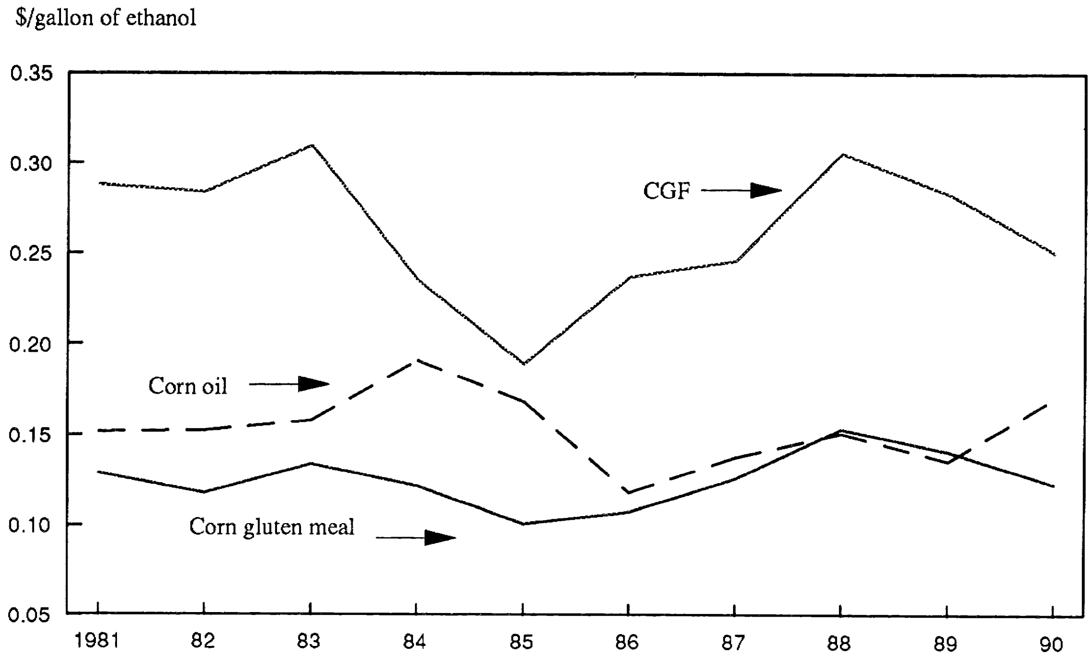
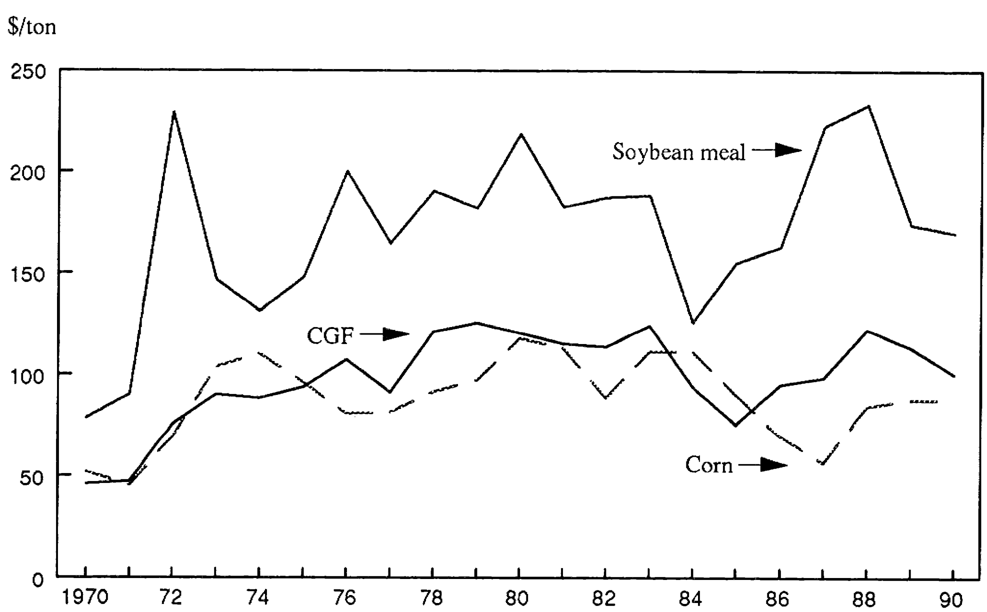


Figure 3

U.S. corn, corn gluten feed, and soybean meal prices

CGF price is generally lower than soybean meal but higher than corn.

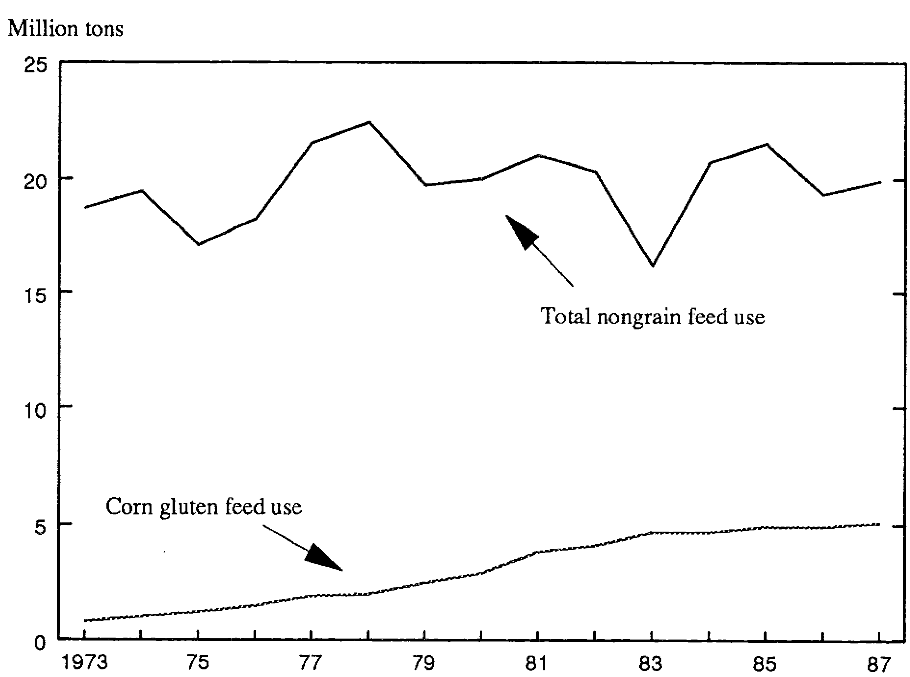


intensive livestock production techniques, which stimulate growth in compound feeds, and (5) strong EC currencies, which encourage imports.

The sustained growth in CGF imports has created a controversy in the EC that centers on the contribution of nongrain feeds to the EC's grain and livestock surpluses. CGF substitutes for EC grains and displaces EC grains in feed rations, thus contributing to the grain surplus. In addition, CGF contributes to the livestock surplus because CGF is a relatively cheap source of feed. The EC has encouraged the United States to impose voluntary export restraints (VER's), while advocating import tariffs and variable levies on nongrain feed imports. Restricting imports (or increasing the price) of CGF would expand the demand for EC grains, reduce the grain surplus, and reduce livestock production.

However, CGF, due to its 22-percent protein content, is a close substitute for other protein meals such as soybean meal. Consequently, any quantitative restrictions or tariffs on U.S. CGF exports would likely increase the EC demand for U.S. oilmeals as well as the demand for EC grains. Several studies have estimated the cross-price elasticities between CGF, grains, and oilmeals, but varied estimation procedures and data availability offer conflicting estimates. Table 3 reports some recent estimates of these elasticities, which show that CGF substitutes for both oilmeals and coarse grains and other ingredients. The degree of substitution depends on livestock type, country or region, and feed ingredient.

Figure 4
Corn gluten feed and nongrain feed use in the EC
While total nongrain feed use has been stable in the EC, CGF use has increased.



Source: Schmidt and Gardiner, 1988.

Table 3--Demand for CGF, selected studies

Study	Method, time period, and region	Commodities covered	Results
Surry and Moschini (1984)	Econometric model, 1961-78, the Netherlands and Belgium	Three feed groups: (1) cereals (corn, wheat, barley); (2) cereal substitutes (manioc, citrus pulp); (3) high-protein (oilmeals, CGF)	Cereal substitutes and high-protein feeds are complements. Cereal substitutes and high-protein feeds feeds substitute for cereals.
Hillberg (1986)	Programming model, 1979/80, West Germany	18 feed ingredients, including CGF	CGF is more a substitute for oilmeals than for grains in cattle rations.
McKinzie, Paarlberg, and Huerta (1986)	Programming model, 1980 price data, 1975-77 nutrition data, the Netherlands	16 feed ingredients, including CGF	Degree of substitution varies across type of ration (dairy, swine, poultry). For total feed industry, CGF substitutes for wheat, coarse grains, citrus pulp, grain byproducts, and oilmeals.
Peeters (1990)	Programming model, 1984/85, 9 EC countries	18 individual ingredients, including CGF; 3 groups of other ingredients	Results vary across countries (CGF substitutes for manioc in France, complements manioc in the Netherlands). CGF and soybean meal are substitutes.

Economic Analysis of Expanding Ethanol Production

Because CGF is a coproduct, supply is determined by the demand for the primary products, HFCS and ethanol. Growth in ethanol production depends on several factors, including the Clean Air Act and the availability of alternative fuels. Increased demand for alternative fuels and continued government support for ethanol production could significantly increase ethanol and CGF output. Over time, HFCS growth will also contribute to CGF production. But growth in the demand for HFCS is expected to be slight because of market saturation (the ability to substitute HFCS for sugar has reached its technical limit) and slow growth in soft drink consumption, the principal use of HFCS. Production of HFCS is estimated to increase by about 2 percent per year from 1992 to 1995.

An increase in ethanol production due to the Clean Air Act would significantly increase CGF production over current levels. For example, an increase in ethanol production to 2 billion gallons in 1995 (from 900 million gallons of ethanol in 1989) would increase CGF production to about 9.1 million tons in 1995 (from 6.8 million tons in 1990). Without reauthorization of the Clean Air Act, CGF is estimated to grow to about 7.9 million tons in 1995.

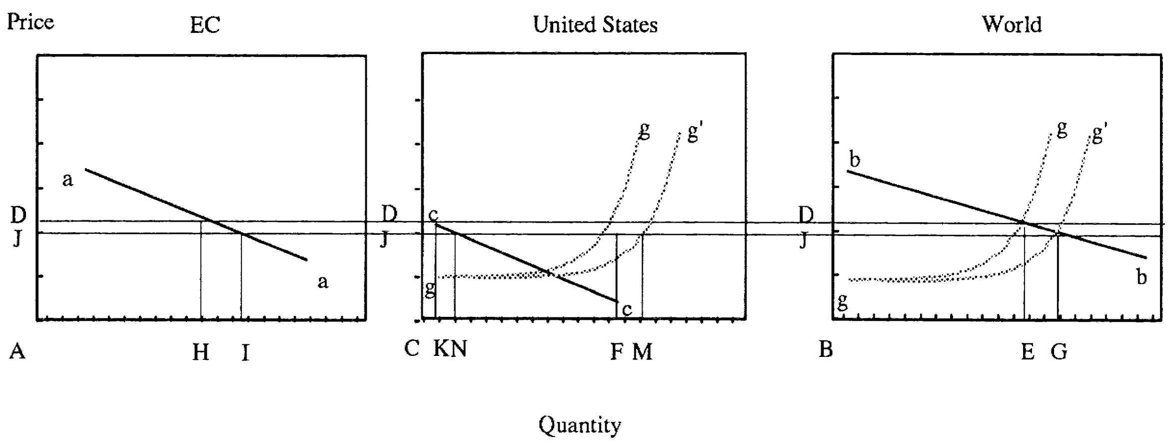
Expanding CGF production will put downward pressure on CGF prices. At the same time, increasing ethanol production will increase corn prices, which will implicitly raise the CGF price floor because the CGF price will not likely fall below the price of corn, given CGF's higher protein content (see box, "Increased Ethanol Production and the CGF Market").

Absorbing additional supplies of CGF that result from expanded ethanol production may also depend on the ability of U.S. suppliers to attract alternative sources of demand for CGF. But existing markets for CGF have arisen due to complex price differentials, substitution possibilities, and the availability of several nongrain feeds. And although there is a worldwide trend toward more compound feeding, large quantities of manufactured feeds are demanded only in fairly developed countries that have invested in specialized livestock operations. Finding alternative markets (outside the United States) for CGF is unlikely in the short run, unless prices fall significantly.

Increased Ethanol Production and the CGF Market

The EC CGF demand curve is *aa*, U.S. CGF demand is *cc*, and world CGF demand (sum of U.S. and EC demand) is *bb*. World supply (which equals U.S. supply) is *gg*. The world price, *D*, is determined at the intersection of world supply (*gg*) and world demand (*bb*). At *D*, world demand is *E*; the United States supplies *F* and demands *K*. U.S. exports are *KF*. The EC demands *H*. Because the EC does not supply CGF, the EC imports *AH* (which equals *KF*).

An increase in ethanol production shifts the U.S. and world supply curve out to *g'*. World price falls to *J* and world demand increases to *G*. U.S. domestic demand increases to *N* and supply increases to *M*; U.S. exports expand to *NM*, which equal increased EC imports of *AI*. Because the relative increase in CGF output (*EG*) is larger than the decrease in CGF price (*DJ*), total revenue to U.S. CGF suppliers increases when ethanol production increases.



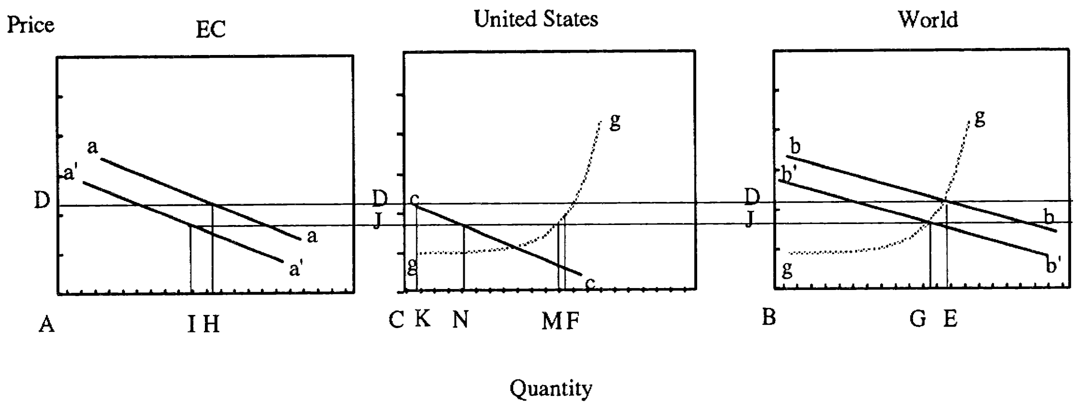
Economic Analysis of Changes in EC Policies

EC demand for CGF could be affected by changes in current EC policy. For example, the proposed reform of the EC's Common Agricultural Policy (CAP) would reduce EC grain prices, increase the use of EC grains in EC feed rations, and reduce the demand for imported CGF (see box, "EC Policy Reform and the CGF Market").

Potential EC policy actions affecting CGF trade include the imposition of quantity restrictions on CGF imports. The EC has periodically attempted to restrict imports of CGF and other nongrain feeds by imposing VERs. For example, in 1981 the EC proposed a VER on CGF and manioc, which is supplied primarily by Thailand and China. French cereal producers strongly supported import controls, while countries with large livestock sectors, such as the Netherlands and West Germany, typically opposed them. In 1982, the EC again advocated restricting imports of CGF to 3.3 million tons (the average of previous years' imports), with additional imports subject to a levy. The proposal was not implemented due to disagreement within the EC and to concerns over the effects of trade restrictions on trade relations with the United States. A VER on CGF would reduce the quantity imported by the EC and raise the price of CGF in the EC (see box, "Economic Impact of a U.S. VER on the CGF Market").

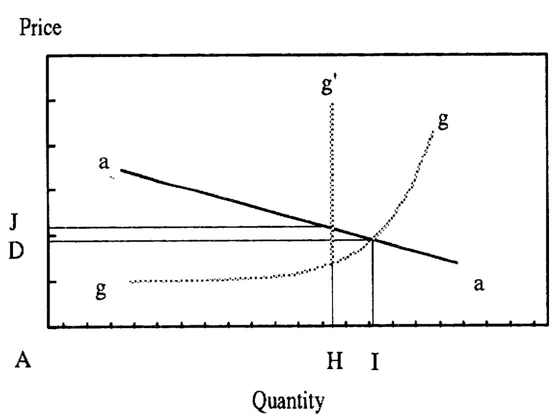
EC Policy Reform and the CGF Market

Again, *aa* is the EC CGF demand curve, *cc* is the U.S. CGF demand curve, *bb* is the world CGF demand curve, and world supply is *gg*. At the world price, *D*, U.S. exports are *KF*; the EC imports *AH*. With a fall in EC grain price, the demand for CGF decreases, which shifts back the EC demand curve for CGF to *a'a'*. This fall in EC demand shifts back world demand to *b'b'* and world price falls to *J*. At the new world price, *J*, U.S. domestic demand increases to *N* but output falls to *M*; U.S. exports decline to *NM* as EC imports fall to *AI*. Again, the effect is clear for the United States; CGF export revenues decline as prices and world demand fall.



Economic Impact of a U.S. VER on the CGF Market

Let *aa* represent the EC CGF demand curve and *gg* represent the EC's import supply curve, which in the case of CGF is the same as the U.S. supply curve. Prior to a VER, EC imports are *AI* and the EC CGF price is *D*. A VER would restrict the level of U.S. exports to *H*, which shifts back the import supply curve to *gg'*. The result of the VER is an increase in the EC CGF price to *J*. The United States sells less CGF overseas but at a higher price. However, the VER will have no effect on U.S. production of CGF. The remaining CGF not sold in the EC must be absorbed in the United States at prices competitive with other nongrain feed ingredients.



Economic Analysis of Increased Ethanol Production *and* EC Policy Reform

In the near term, the CGF market will likely be affected by both price reforms in the EC and an increase in ethanol production (table 4). In May 1992, the EC adopted a package of CAP reforms. The reforms, which will be phased in over time, will lower EC support prices and establish acreage set-aside requirements. By 1995, the Clean Air Act could result in 2 billion gallons of ethanol production per year, increasing CGF supply 15 percent over its level otherwise (9.1 million tons compared with 7.9 million tons).

A reduction in EC grain prices would increase the use of EC grains in EC feed rations, reduce the demand for CGF, and lower CGF prices. An increase in ethanol production also puts downward pressure on CGF price. However, increased ethanol production raises corn prices. Because CGF price is not likely to fall below the U.S. corn price, the increase in ethanol production helps cushion the fall in CGF prices. The net effect of CAP reform and expanded ethanol production is lower CGF prices, increased use of CGF in the United States, and substitution of grains for some CGF in the EC.

Preliminary estimates indicate that a 30-percent decline in EC grain prices (as is possible under the proposed CAP reform package) would result in a fall in EC CGF prices of about 30 percent (see box, "About the Model"). A simultaneous increase in U.S. ethanol production to 2 billion gallons puts additional downward pressure on CGF prices. Although CGF prices fall, CGF is still priced competitively with EC grains and imported oilseeds, and, consequently, CGF continues to be used in the EC. The EC would likely continue to import a large portion of total U.S. supply. However, as CGF prices fall, U.S. feed manufacturers will bid away CGF from the export market. Wet-millers would be able to dispose of the increased supply of CGF, but at lower prices. As prices for CGF fall, due to increased CGF supply and EC grain price declines, the CGF coproduct credit will also decline, affecting the cost of wet-milling. For example, when CGF is priced at $110/ton (roughly the price in the late 1980's), the CGF coproduct credit as a proportion of total wet-milling coproduct credits is 51 percent. If CGF prices were to decline to $80/ton (a 27-percent decline), the CGF coproduct credit as a proportion of total wet-milling coproduct credits falls to 43 percent, reducing the profitability per ton of wet-milling. At the same time, the increase in the demand for CGF in the United States has a positive effect on wet-milling revenue.

Table 4--Summary of likely policy changes: effects on CGF market (relative to 1990)

Item	EC policy reform[1] (A)	Expanded ethanol production[2] (B)	Combination of policies (A+B)
EC CGF price	Decrease	Decrease	Decrease
U.S. CGF supply	No effect	Increase	Increase
U.S. CGF exports	Decrease	Increase	Uncertain
U.S. demand for CGF	Increase	Increase	Increase

[1] EC grain prices decline; EC demand for CGF falls.
[2] U.S. ethanol output expands; CGF supply expands.

About the Model

An EC feed grains model is used to simulate the effect of a reduction in EC grain prices coupled with an increase in ethanol production. The model used is a partial equilibrium, static EC feed grains model that covers 23 feed ingredients and 4 livestock categories. The model illustrates the impact of policy changes on the CGF market. Estimates were provided by Bill Quinby, Economic Research Service, U.S. Department of Agriculture.

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Emerging Technologies in Ethanol Production (AIB-663)

The fuel ethanol industry is poised to adopt a wide range of technologies that would reduce costs at every stage of the production process. Improved enzymes and fermenter designs can reduce the time needed to convert corn to ethanol and lower capital costs. Membrane filtration can allow the recovery of high-value coproducts such as lactic acid. Adoption of these and other innovations in the next 5 years is expected in new ethanol plants constructed to cope with new demand resulting from Clean Air Act stipulations for cleaner burning fuel. Biomass (agricultural residues, municipal and yard waste, energy crops like switchgrass) can also be converted to ethanol, although commercial-scale ventures are limited by current technology. (Order from address below, $9.)

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Expanded ethanol production could increase U.S. farm income by as much as $1 billion (1.4 percent) by 2000. Because corn is the primary feedstock for ethanol, growers in the Corn Belt would benefit most from improved ethanol technology and heightened demand. Coproducts from the conversion process (corn gluten meal, corn gluten feed, and others) compete with soybean meal, so soybean growers in the South may see revenues decline. The U.S. balance of trade would improve with increased ethanol production as oil import needs decline. (Order from address below, $6.)

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